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ABSTRACT

This case study involved the incorporation of prototype multimedia instructional materials into a fifth-grade classroom in a public elementary school for a period of 6 weeks. The research was conducted in the Hillcrest School in a suburb of New York City. Shortly after their introduction into the classroom, microcomputers, interactive video technology, and computer-assisted instructional programs became part of the classroom culture and were being used by students for game-playing, research, and the creation of individual and collaborative presentations and interactive multimedia "reports." In this mode, students used computer software tools to select, construct, and revise ideas with moving and still images, text, and sounds, creating products that included visually annotated reports and narrated presentations. This report describes the highlights of children's work as multimedia "authors" and details the conditions that surrounded and supported their work. It is concluded that the introduction of multimedia educational technologies into supportive schools and classrooms is not only highly successful, but also becomes a vehicle for small group instruction and the creation of original products that further students' research and participation in learning. Eight notes and a list of 87 related articles conclude the report. (Author/DB)

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Classroom Integration of Interactive Multimedia: A Case Study

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CLASSROOM INTEGRATION OF INTERACTIVE MULTIMEDIA: A CASE STUDY

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New interactive multimedia tools and applications are becoming available for use in classrooms, but little is known about the nature and value of using such materials nor the conditions which might best support their integration into classrooms. This paper describes a brief exploratory look at what can happen when multimedia hardware and software are introduced into a supportive school and classroom setting. Within a few weeks of their introduction into a fifth-grade classroom, multimedia materials had become part of the classroom culture and were being used by students for game-playing, research and, most interestingly, the creation of individual and collaborative presentations and interactive multimedia "reports." In this mode, students used multimedia software tools to select, construct, and revise ideas with moving and still images, text, and sounds, creating products that included visually annotated reports and narrated presentations. This paper describes the highlights of children's work as multimedia "authors," and details the conditions that surrounded and supported their work.

PROCEDURE

Our research was conducted in the Hillcrest School, a public elementary school located in a well-to-do suburb north of New York City.[1] We observed a fifth-grade class of seventeen students taught by Lucy, who had been teaching at Hillcrest for more than eight years. Lucy and her class were assisted in their multimedia experiment by Richard, a science curriculum coordinator for the school district, and Sam, an elementary math and science coordinator, who provided intermittent support and advice in implementing the program. Over the six weeks of use, researchers observed the class' use of the multimedia system five times, videotaping each two-hour session. Researchers acted as participant-observers, freely interacting with students and teacher, and occasionally intervening to help resolve confusions with the software or to ask questions about the students' thinking process. Observations were supplemented by videotaped interviews with Lucy, the two administrators, and four student users.

Hardware and Software

The multimedia system used included a Macintosh computer, a Pioneer videodisc player, and a prototype videodisc and computer software (supplied by the researchers), as well as a monitor and two additional videodiscs (supplied by the school).

The software used was *Interactive NOVA: Animal Pathfinders* (WGBH-TV, Boston; Peace River Films, Apple Computer, Inc., 1990), a then prototype program on animal migration that combines HyperCard computer software with video images and sounds on videodisc. The program offers Overviews to introduce users to the basic operations and ideas in the

material, a Database that allows students to search and sort through information about various animals and habitats, and Activities, including a simulated field study of monarch butterfly migration, an exercise in interpreting bee dances, and an investigation of human threats to sea turtles. In addition, there is a Resources section of the software that allows students to make multimedia reports and presentations using on-line video-editing and report-maker tools.

The two additional videodiscs used were National Geographic's Whales (1983) and *The Voyage of the Mimi* prototype videodisc (Bank Street College of Education, 1985).

The software was chosen by teacher and researcher consensus from a range of multimedia design examples because of the breadth and richness of its content, the clarity of its interface, its apparent accessibility to students of varying abilities and learning styles and, in particular, the coherence of its authoring tools.[2]

RESULTS

Learning to use the multimedia materials and tools was not difficult for the children. After an initial introduction to the system by Lucy, they proceeded to discover its features by trial and error, and by sharing their expertise with others. The multimedia system remained in Lucy's classroom for six weeks. Over this time about three fourths of the children worked with it in one or more of the three main modes (database browsing, activities, and report making). Approximately one third of the students chose to work in the latter, most intensive mode. The program was used before, during, and after school, and as word of it spread around the school, interested students from other classes would come during recess to use it as well. The more concentrated report making often happened at lunch time and during designated class periods. In all three of the modes, children worked alone, in pairs, and in small groups, with only occasional input from Lucy.

DISCUSSION

In the discussion that follows, we emphasize three dimensions of the multimedia work that went on in Lucy's class: (I) the image provided of "integrated" multimedia use; (II) the glimpse offered of multimedia "authoring" as both process and product; and (III) the ways in which integration was supported by aspects of the teacher's style, the school environment, and the design of the software.

I. Multimedia as Integrated Technology

Technology integration means at least three things: embeddedness in a curriculum; continuity with the prevailing pedagogy; and physical and temporal accessibility. First, integrated use of technology means computer use that happens within a meaningful *curricular* context organized by the teacher. It may be a unit on plane geometry, the study of blacks in the Civil War, or an effort to understand *Hamlet*; the criterion is that technology use, instead of being an isolated vehicle of learning, serves a larger curricular aim. As such, it may be surrounded by other activities such as group discussion, writing, or research with other sources.[3] Second, technology-based materials are integrated *pedagogically* if their organization and function fit the style of teaching that prevails in the classroom. For example, a program that approaches Greek history through a computer-simulated archeological dig will be more easily integrated into classrooms where open-ended research projects are the norm than it will in those where history is approached as names, dates, and events to be lectured about and memorized. Third, technologies are integrated *physically* and *temporally* if they are accessible to students and teachers where and when they need them. This may mean being located in or adjacent to the classroom instead of being concentrated in, for example, a separate computer lab.

Hillcrest's multimedia system became integrated into Lucy's classroom in each of these ways. The curricular connection was established by Lucy herself, who wanted to use materials that could supplement her class' study of a topic they had been working on all year—whales and marine life. She saw Interactive *NOVA: Animal Pathfinders* and the additional discs on whales as vehicles for extending students' inquiries into a subject they were already quite knowledgeable about. Their study of whales had been under way for quite some time and had included the use of Bank Street's *Voyage of the Mimi* materials, as well as reading the novel *The Island of the Blue Dolphins*. Many of the students had just completed written reports on whales, illustrated with drawings and, in some cases, papier maché whales, at the time Interactive *NOVA* was introduced. Lucy invited her students to explore the images, sounds, and text information in the *NOVA* pro-

gram, and see whether they wanted to create something that related to their prior reading and research.

The multimedia system was also integrated physically and temporally into the classroom environment. Placed on a rolling cart, the materials were kept inside the classroom throughout the period of use, and they became treated much like any other classroom resource, such as encyclopedias, drawing materials, or reference works: Children consulted them as their interests, needs, and time dictated. While not invisible, the system was not visibly intrusive nor was students' use of it disruptive to others working on other projects. For Lucy, the system did not change the "flow of activity" in her classroom, but enabled her to continue moving about and helping students with whatever projects they were working on.

Finally, Lucy's style as a teacher—she saw herself as a guide to students in their inquiries—was in concert with the pedagogical orientation of the software. At the general level, the program's flexibility and open-endedness as a database fit her student-centered approach. More particularly, Lucy's emphasis on self-directed research and expression (through writing, drawing, and making) found an echo in the authoring components of the NOVA materials. Students who used the program's Report-Maker and Video-Editor tools to create reports and presentations were engaged in a kind of work they were quite familiar with. For example, it was not unusual for most of the class to be working on independent projects at the same time, with a great deal of movement, talk, and collaboration going on, and Lucy moving about as "coach" to student inquirers. Significantly, Lucy did not require that students create multimedia reports, but only encouraged those who expressed an interest in doing so.

II. Multimedia Authoring: Some Initial Questions

Interactive multimedia is a relatively new environment for student authoring. Our questions, therefore, were straightforward: First, would authoring be an *engaging* activity, and if so, for what kinds of students? Second, what form would the *products* take, and how would they be interpreted? Most important, what kind of *process* would their creation involve? How would the curricular context shape the students' aims and approaches? Would this multimedia system support collaborative as well as individual authorship? What kinds of guidance would be needed to help support student revision? Finally, what relationships to sources (videodiscs, books, computer data) would student authors cultivate?

Engagement

For the students who chose to do so, creating multimedia products was a very engaging activity. Among the seven or eight students who experimented with the software authoring tools in some way, four persisted long enough to create finished multimedia products: *Laurie*, an extremely bright and mature girl who excelled at reading and writing; *Jeff*, a somewhat inward boy whose attention span tended to be quite short; and *Nancy* and *Helen*, two close friends who liked to work together on projects.[4] In using the system, these four students became engaged in ways that Lucy had not seen before. Laurie, who had not previously shown any interest in science, technology, or math, spent much of her spare time creating and revising two separate presentations, and in doing so became the class expert on the system, the resource to whom other students went when they needed help using a particular feature. Jeff also worked alone on a presentation, but because of the public nature of the product, according to Lucy he ended up "exposing himself in front of others" in ways she had not seen before. Finally, Nancy's collaboration with Helen on the system was engaging enough that she saw their presentation through to completion, something she had great trouble doing with her other work.

Multimedia Authoring: The Products

The multimedia products students created took two general forms, both shaped by the software tools. *Visually annotated reports* were created using *NOVA's* Report-Maker features, and consisted of a linear sequence of written "note cards" (appearing on the computer monitor), each of which was accompanied by a motion video segment or one or more still images (appearing on the videodisc monitor). *Narrated videos* were created with the program's Video-Editor features, and consisted of video clips and slides arranged in sequence and played back under student control, accompanied by the "author's" verbal narration.

Both annotated reports and narrated videos had a status as *performance* that these static descriptions fail to convey. While being presented to others, both kinds of products were embellished in several ways by their authors: through gesture, through verbal elaboration,

and through interactions with the audience (sometimes other students, sometimes the teacher, and sometimes the researchers). For example, an author might read each text card aloud (in a report) or spontaneously invent narration (for a video), while pointing out the relevant parts of the accompanying images with gestures.[5]

In a visually annotated report, images tended to reinforce the text, the main carrier of meaning, by providing examples and illustrations. Eleven-year-old Laurie's report on sea lions initially mimicked the straightforwardly factual, descriptive style of the software database, with images as illustrations; later revisions became more evocative and directed the reader's attention to specific parts of the video images.[6]

In comparison with more traditional written reports, students' multimedia reports were shorter overall and more telegraphic in style, due to the authors' assumptions about how readers would interact with the material. As Laurie explained:

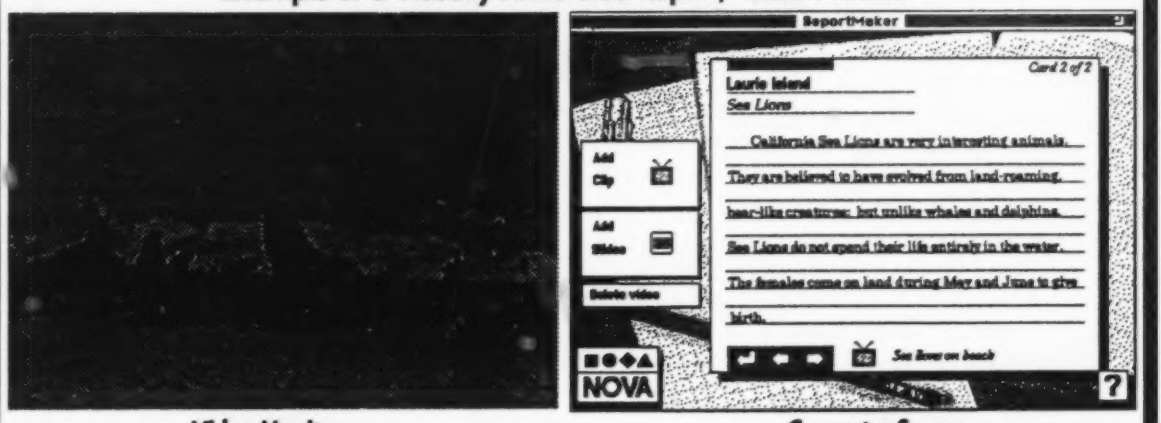
> You write less here than in the paper report because here you can see more (from the videodisc images), and with the paper report you'd have to tell more because you couldn't see. In the paper you'd explain with words how they dive, how they move their flippers; here you see it. In the multimedia report you assume that people will look and that you don't have to tell them things in writing.

In a narrated video, images were the focus of attention and were accompanied by students' prepared or improvised narrations. (The computer served as the means of sequencing and playing back video images.) For example, Laurie's narration for the image above (taken from a motion clip) was:

> These pictures are of what people used to think whales looked like—they don't look like real whales, because whales are very gentle and beautiful creatures—they look like the body of a fish with the head of a wolf or a fox or something. People would draw these after they would go whaling; they thought that the whales were terrible sea monsters, and that's why they thought that it was okay to kill them. They thought that whales could really hurt them.

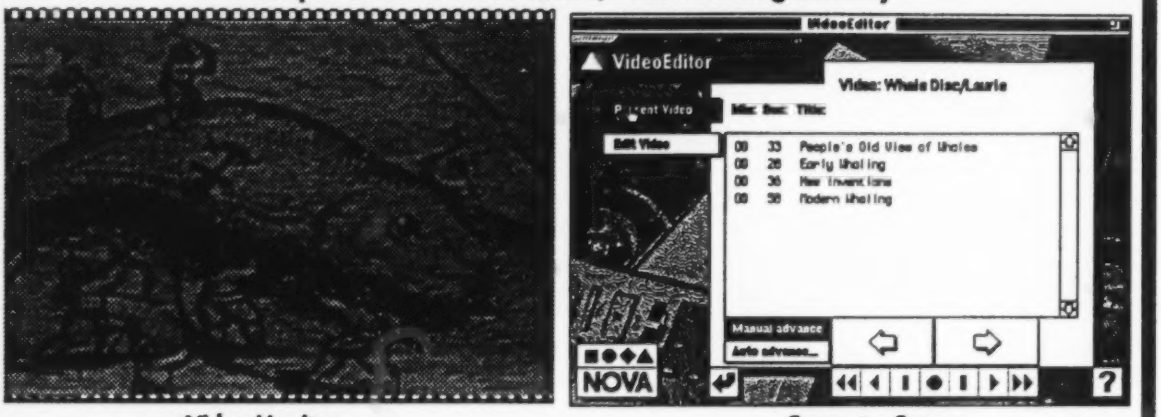
In general, students' narrated videos achieved a greater seamlessness of information and integration of media formats (images, words, gestures) than their annotated reports. Spontaneous narrations were often smoother, more varied in tone, and more aware of the listener than were the text entries in reports. This may have been due both to the familiarity of documentary video conventions of voice-over narration and also to

Example of a Visually Annotated Report, "Laurie Island"



Video Monitor Computer Screen

Example of a Narrated Video, "The Whaling Industry"



Video Monitor Computer Screen

the greater salience of the audience in the narration of the videos.

Authoring as a Process

The general pattern students followed in creating multimedia reports included initial browsing of the images and text, the identification of a topic, the writing of text "cards," a search for appropriate images, and revision of the text and/or images selected. The text initially typed was usually adapted from the students' previously written reports. Children selected images according to several different criteria. As a general rule, they tended to choose motion over still images, and images that were literal illustrations of the topic at hand rather than those that required explanation, even if the latter might be more visually interesting. Over time, however, as children became more adept in handling images and text together, their ability to use and explain more diverse and interesting images increased. Where children had more opportunities (time, guidance, etc.) to revise, the more the visual and textual components were articulated toward one another in a mutually reinforcing way, and the more the text came to embody their own unique voices.

If in making reports students tended to start with text and add images, the process was often reversed in the creation of videos. Children began by choosing images that appealed to them, arranging these in a sequence that made sense to them, and playing back the sequence with their own voice-over narration as Ralph (one of the administrators who actively supported our multimedia experiment) videotaped them. Revision occurred in the rearrangement of clips and stills, and in the spontaneous changes students made during the performance of their videos.

Children's approach to the task of multimedia authorship, and especially their ability to revise their productions, was influenced by the curricular context of the work, the structure and content of the software, the size of the working group, the guidance of adults, and the differing personalities and styles of the students themselves. In the next section, we illustrate the role of curricular context and student personality in supporting revision with reference to Laurie, examples of whose work are shown above.

Laurie: Independent Authoring with a Purpose

Perhaps more important than anything else in engaging and sustaining students' efforts was the sense they had of coming to the materials with a purpose, and with some expertise on a topic contained in the materials. As we have said, nearly all had spent a great deal of time studying whales and the marine environment, and each had written her or his own report on a particular type of whale. Students had also read fiction related to marine habitats, and many had written

book reports in response to this fiction. With this experience behind them, many students approached the materials with a desire to see whether or not "their whale" was included and, if so, whether their own expertise would be validated by the images and information the program contained.

Laurie, a very proficient reader and writer, wrote her initial report about sea lions, sea otters, and elephant seals, inspired by her reading of the novel *The Island of the Blue Dolphins*. She had changed her topic from the whaling industry (the topic of her written report) after playing the activities in *Interactive NOVA* and browsing through the database and videodisc images, where she could not find images of the whaling industry. She did, however, see some "really pretty pictures" of sea lions, which looked "really graceful under water." Having decided on her topic, Laurie began her multimedia report by writing text on "a lot of cards" and adding slides from the *Interactive NOVA* videodisc that related to her written text. She gathered information from external sources (books from the classroom and from home), as well as using information contained in the *Interactive NOVA* database. As she became more comfortable with this process, she started to replace some of the slides with motion clips, which she frequently customized in length (changing start or stop points) using the video editing tool. Laurie's process, then, was basically cyclical, consisting of writing out her ideas on cards, first in a particular sequence, then illuminating them with videodisc slides and motion clips, then customizing the motion clips, then adding more cards.

At this stage, Laurie was careful to choose slides and motion clips that illuminated her written text, though the illustration was just that—a supplement to her factual text material. Ralph noticed that Laurie's previous written assignment on whaling had contained much more evocative language and a variety of forms of address. He mentioned this to Lucy, who suggested that Laurie try to add some of this narrative voice to her multimedia report. In response to this, Laurie revised the text of her sea lion report to include direct addresses to the viewer and references to the "shots" on the videodisc, calling attention to particular features of the image and specifying the transitions between images as "close-ups" and "zooms." The language of this revised report was also far more evocative than her initial effort, using adjectives to describe the motions and colors of the video images. At this stage, the video images became co-equal with the text; the text illuminated the images as often as the images illustrated the text.

Her report done, Laurie now discovered an assortment of images related to whaling on the National Geographic Whales videodisc and, still enthusiastic about creating multimedia products, began working on a video about the whaling industry, the topic of her original written work for Lucy. With Ralph as cameraman and audience, she taped her own narration of this video. Here, Laurie's expertise about whaling converged with the flexibility of the multimedia system (a sequence of customized and evocative pictures and sounds was directly under her control) to create a powerful synthesis of images, words and gestures, general ideas, and detailed evidence.

As a talented and independent student, Laurie found the "room" that multimedia authoring gave her to edit and alter to her needs normally "untouchable" material one of the medium's most attractive features. As she described her video-making experience, "I made my own film by putting a lot of the clips they had together and changing them around." Once aroused, her impulse to customize the material toward her own aims led her up against the limitations of the system. Characteristically, however, she enumerated changes she would like to see in the next generation of authoring tools, including the ability to "marry" separate video clips, and to add her own audio narration without using a separate video camera, as she had done with Ralph. When asked what she had learned from her experience with the multimedia system and software, Laurie said she had learned "how to use a videodisc player, a lot about the computer, and a lot about sea lions."

Jeff: The Limits of Collaboration and the Need for Guidance

Aware that not every student had Laurie's independence of mind, Lucy encouraged several children to collaborate with one another on the creation of a group report. In the end, however, collaborations of more than two students did not occur successfully in our brief experiment. Due to the size and brevity of the study, it is impossible to know precisely why this was so, but likely contributors include the physical configuration of the hardware (which made it difficult for more than two students to sit directly in front of the

system); the design of the software (which is very open-ended yet allows for, at most, two students to have meaningful input at any one time); the complexity of the authoring task (which requires a degree of concentration that is difficult to achieve with more than two users); and again, the personalities of the students. Each of these factors introduced a degree of "noise" into the authoring process, making it easy for students to get off track and lose their momentum (for example, by getting diverted into browsing, playing with images, or arguing over control of the software). Guiding interventions by Lucy, the researchers, and other "expert" children were critical in reducing this noise and getting children back on track. While such guidance was not always successful in getting groups to collaborate, it was indispensable, as Jeff's experience shows, in helping some individual student authors complete their multimedia products.

Jeff was a boy whose concentration often flagged, and Lucy initially suggested he work with three other partners—John, Debby, and Sabrina—in exploring the software. This particular foursome had never worked together before and found it difficult to coordinate their efforts at navigating around the program. The difficulty with which the multimedia program could accommodate four diverse users at once was illustrated by the problem of typing. When typing became necessary in the course of making a report, Jeff was not inclined to relinquish his seat at the keyboard, despite his lack of typing skills; Sabrina, a better typist, was left to try to type for him over his shoulder. Sensing a lack of focus in this group, Lucy came by and suggested that they use the report-maker and/or video-editing tools to make a collaborative report that combined all of their whale reports. As they proceeded to look for images and decide on their topic, they needed considerable help from the researchers in using the various options on the screen. For example, they were confused at first about the differences between the report-maker and video-editing tools. Noting the remaining confusion about the groups' aim and individual roles, the researchers suggested they assume different "production" roles: director/scriptwriter, program navigator, typist, selector of images. Despite this structuring, they continued to need a lot of prompting and support in the use of the interface options and had trouble assuming their roles without bickering and fooling around. In the very brief (two-card) report that they did manage to create in their forty-five minute session together, the text was copied directly from the text of Debby's written report on grey whales.

After this initial group session, Jeff worked with *Interactive NOVA* alone. After seeing Laurie's report on sea lions, he decided to write what he hoped would be a similar report on the killer whale, the topic of his previous written assignment. When his initial search for images failed to turn up many useful pictures on the *NOVA* disc, he decided to look for images of killer whales on the National Geographic *Whales* disc, and did so with the researchers' and Laurie's help. (Laurie had become class expert in the use of the multimedia tools, even learning how to use discs that were not perfectly compatible with the software, but whose images could be used to advantage.) Jeff's search through the videodisc generally lacked focus. He became so excited by most of the clips on the disc, even those unrelated to his topic, that he quickly forgot what he was looking for and started writing down the frame numbers of every clip he liked, regardless of topic. Jeff's difficulty in logging frame numbers indicated that he did not understand the format of the videodisc very well at this point. He was also prone to digressions and might, for instance, stop to play with other, more amusing images while in the middle of his search for killer whale images. With a lot of researcher prompting, Jeff eventually found and logged a few clips related to killer whales, and typed text cards according to categories that he transposed from his previous written report, titled "The Pod," and "What They Eat." Throughout, Jeff continued to need assistance in the use of the various *Interactive NOVA* software tools, and sometimes turned to fellow students who were more experienced than he.

Finally, with Ralph's encouragement, Jeff too was able to narrate a video based on his multimedia report, and here he seemed to take pleasure in performing what he knew, supplementing the prerecorded videodisc audio with his own complementary narration. Lucy, seeing his video, commented that she rarely saw him risk displaying himself in front of others in this way.

Nancy and Helen: An Emerging Awareness of Source Materials

Our brief study of multimedia authoring did not allow us to evaluate a range of outcomes that future research should examine, from the effect on students' writing

to their ability to discriminate and synthesize disparate forms of information. One unexpected outcome, however, warrants even speculative mention. For the students we observed, the authoring task appeared to develop an awareness of the nature, scope, and even the limitations of the multimedia source materials that their work in other modes, such as browsing or game playing, did not provoke.

An awareness of sources is important because most multimedia materials are of uncertain scope. Students may encounter thousands of still and motion photographs and graphic illustrations, as well as a large textual and graphic database, yet have difficulty in knowing at a glance what is included and what is not. A computer software database and videodisc, unlike more conventional resources such as books, do not outwardly convey any idea of the amount of information they contain, and rarely contain reliable conventions for conveying content scope, such as tables of contents and indexes. In approaching the system as authors with a sense of the ideas they wanted to communicate, students browsed much of the material serendipitously, and came to evaluate individual images and text cards according to whether they might further their ideas. As they came to understand how limited (and, in some cases, arbitrary) the materials' scope was, children's initial disappointment at not finding exactly the images they wanted was replaced by creative efforts to use and explain more approximate representations. In doing so, they seemed to develop a realistic assessment of the materials' strengths (often striking images that could be rearranged) and weaknesses (a somewhat arbitrary selection of images and information) and saw the value of consulting different sources of information. Laurie, for example, ultimately brought several books from home into class, since they contained more general information about sea lions than the disc contained. She came to understand that some videodiscs, like books, "have less information than others," but that "you can learn things from the videodisc pictures that can't be shown in a book, like how the sea lions move their flippers and stuff when they swim."

The process of negotiating different sources was best illustrated in the collaboration between Nancy and Helen, two friends who had developed a shared interest in toothed whales while working on separate research reports. They began their use of Inter*active* *NOVA* by browsing through the database cards and videodisc images. After deciding to create a multimedia report on narwhals, the subject of Nancy's earlier research, they looked through the *NOVA* disc together for appropriate video segments. They quickly discovered, however, that the disc and software focused on California grey whales and did not include pictures or information on most other whales, including narwhals. Determined not to give up, they enlisted Laurie's help in replacing the *NOVA* disc with the National Geographic *Whales* disc, even while using the original *NOVA* software to control it. Yet, to their disappointment, Nancy and Helen did not find images of narwhals on the *Whales* disc either. At this point, instead of switching topics, they noticed that the *Whales* disc grouped toothed whales separately from baleen whales and decided to reframe their inquiry as a report on the *narwhal as an example of toothed whales*. This reframing set up a problem whereby they would have to take account, in their presentation, of the relation between a general category (toothed whales) and a specific example (the narwhal) for which no pictures were available. Accordingly, they browsed information and pictures about the feeding habits, nursing, migration, and echo location of toothed whales, noting the frame numbers of relevant pictures. They then added these to the text, already entered, that had been transcribed, with some modifications, from Nancy's earlier narwhal report.[7]

At first, then, Nancy and Helen's multimedia report was marked by a discrepancy between image and text, consisting of text cards chiefly about narwhals, accompanied by video images of other toothed whales. In some cases, entirely different species of animals were included, as when the card describing the narwhal's tusk was illustrated by a picture of a walrus tusk. The connections that Nancy and Helen had clearly made in their minds and in their conversation—for example, that between "narwhal tusk" and the more general category of "mammal tusk"—were not yet apparent in the product they had created. The presentation of their report to an audience, however, provoked explanations that demonstrated their grasp of the relationships involved. They explained, for example, that the narwhal's tusk was essentially a large tooth and that, as mammals, toothed whales could have features that resembled quite different animals.

Their awareness of the multimedia materials' scope enabled Nancy and Helen to compare these materials

with the resources, and the products, of their more traditional research. Nancy, for example, felt that the system was "not a good place to do research," compared to the books she had used in preparation for her written report, which tended to have "more detail." But she felt the system "was really fun to write on because it's something different. Instead of writing on paper, you write on cards and add clips and slides." Helen felt that Interactive *NOVA* could be used for research as well as for writing, but only for researching topics that were available on the disc. Both students thought the process of browsing through images serendipitously, however, was useful and fun:

> I enjoyed this very much. It was really interesting to find the different pictures. We learned by what [the audio narration and text] told us, and by the pictures.

Finally, Nancy and Helen's authoring experience led them to suggest changes in future multimedia resources for student authoring. Regarding the structure and scope of the database, they felt that discs devoted to covering one subject area in greater depth and from a variety of perspectives would be more useful than a broad and shallow database covering many different items. "Things were too scattered around," said Helen, for example, "Why not have each disc organized by one subject?" Nancy, too, wished that there were more motion clips of all kinds of whales, and more variety within the whale category, available on one disc. She suggested that "there should be a different disc for each animal with lists of slides and clips." The students also thought that the software should provide more explicit opportunities to include information from other sources. As Nancy said, "The index makes you think you're limited to the NOVA disc, but you can add pictures from other discs and writing from books." Finally, the experience they had of creating their own sequences of images led Nancy and Helen, like Laurie, to wish they had even more control over standard editing functions, such as the ability to "put two clips together from different parts of the same disc and to be able to have more than one motion clip per text card."

III. Conditions That Supported Multimedia Integration

Everyone associated with the exercise—students, teachers, and curriculum administrators—declared Hillcrest's brief experiment with multimedia a success. Laurie described the experience as "fun—hard work, but mostly fun. I made my own film . . . and learned a lot about the computer, and a lot about sea lions." Lucy felt that multimedia "was a wonderful addition to the class . . . the kids have had a wonderful time with this and have learned a tremendous amount." Sam, the curriculum coordinator, was "encouraged that the kids could understand all of this, and that they got help from each other."

But the successful integration of *Interactive NOVA* did not happen overnight, nor was it an outcome brought about by any magical feature of multimedia technology itself. Several key factors combined to create the supportive conditions in which these multimedia materials could be so successfully absorbed into the culture of the classroom: the role of the teacher; the role of the administrative support staff; the role of district, school, and classroom environments; the role of the software design; and the role of the researchers.

The Role of the Teacher

It is the classroom teacher who is most responsible for the success of any educational innovation. In this brief experiment with multimedia authorship, Lucy played a critical role in interpreting, introducing, guiding, and supporting her students in their work with the new materials and tools. As a teacher she cannot be called unique, because she combines so many of the qualities that are widely regarded as desirable in a teacher; but, by the same token, she cannot be called typical. A brief resume of these qualities, and their role in guiding the integration of multimedia work, follows. It includes her previous *experience with technology*; her eagerness to risk trying new things, and to *seek the help of others* in doing so; her *dedication* and conscientiousness; and the openness and flexibility of her *teaching style*.

Compared to many of her colleagues, Lucy was quite comfortable with technology. She had become Hillcrest's de facto computer coordinator by virtue of having used computers for several years in conjunction with the science and mathematics program, *The Voyage of the Mimi*, and in other contexts. She had also taken several of the technology-related courses offered by the school district's teacher resource center, including one on the use of multimedia materials. Most important, as a consequence of her experience with different media, was her ability to envision tech-

nologies as only one facet of a rich classroom environment, something to make use of, when appropriate, for certain ends, for certain students.

Despite her relative familiarity with technology, however, Lucy initially felt apprehensive about tackling multimedia authoring in her classroom, primarily because of the "lack of success" she had felt in a teacher course that had involved using computers to make multimedia materials. Because of this, and because she had never before used a Macintosh computer in her class, Lucy initially felt "very apprehensive, even overwhelmed" about having the multimedia system in her classroom. She "wondered how it would work, felt unclear and fuzzy, was sure it would not work out," and even said to herself at one point, "forget it." Her apprehension was overcome, however, by other things: her interest in taking risks, her willingness to embrace the role of learner, and her ability to draw in others who could help her. After securing promises of help from Sam and Ralph, two administrators who had introduced her to the researchers, she said she "looked forward to her role as a novice, learning with the students, rather than having to know everything" about the materials ahead of time.

A hardworking and conscientious teacher, Lucy's sense of responsibility to her colleagues and to her students led her to spend several hours after school on two consecutive days becoming familiar with the operation, navigation, and content of the multimedia tools and materials. She asked the researchers for paper printouts of several screens and the keyboard and icon functions for reference. Having prepared herself, she also wanted her students to have as thorough an introduction to the materials as possible, so she spent one hour on two more days explaining them to the class as a whole. During the first session, she described the equipment and showed the class how to search, using a software version of the videodisc remote controller, for video clips and stills on the Interactive NOVA and National Geographic videodiscs. During the second session, she demonstrated the report-maker and video-editor tools of the *Interactive NOVA* software, and suggested that students who were interested might create multimedia reports about whales that could complement their current assignment to create written reports and/or oral presentations about one type of whale.

Lucy's style of teaching, in particular her orientation toward student-centered learning, was equally important in helping her to integrate *Interactive NOVA* into her classroom, for it allowed her to let the students find their own way of entering into the material. Once the equipment was in her class and she saw the kids using it, she said, her fears went away. She quickly saw that it was easy and enjoyable for them to use, and she noted how quickly they absorbed the terminology of multimedia editing in their casual references to "clips" and "frames." For her, it was "never a disruption" to have some students using the system while others were working on other tasks. She monitored children's work on the system about as much as she monitored other kinds of work, both to provoke thinking or reflection and to manage kids' behavior. She also noted that the clarity of the software made it possible for kids to share time on it without constant structuring and support from her.

Role of Administrative Support Staff

Our multimedia experiment also drew on key supports available at the administrative level. Lucy was assisted in her multimedia experiment by two school district professionals: Sam, a senior curriculum coordinator in science who also heads the district's technology-rich teacher resource center; and Ralph, the Hillcrest School's math and science enrichment specialist. Both Sam and Ralph were interested in using technology to promote curriculum innovation. In particular, they wanted to promote two levels of involvement: having teachers use multimedia software to design materials, and having students use multimedia software to do research and make reports. Their interests, as well as Lucy's, had helped determine the focus on student research and report making using on-line multimedia production tools.

Ralph, especially, was "on call" whenever Lucy encountered a problem with the software. In the course of the six weeks of use, he responded to such calls only twice, but his promptness helped reassure Lucy that she could negotiate the new technology successfully. It was also Ralph who, aware of Lucy's desire for hard copies of children's multimedia work, set about videotaping students' presentations of their work so that she and the students had something to look at, reflect on, and take home with them. Ralph also had a researcher's interest in the way that the materials functioned in the class. He cautioned that, while Lucy embraced the medium quite easily, other teachers

would probably want and need more structure and support from him than she had.

Role of the District, School, and Classroom Environment

Hillcrest's school district, the school itself, and the environment of Lucy's classroom also played important roles in supporting our multimedia experiment. The school district was, first and foremost, relatively sophisticated in its approach to the use of technologies in teaching and learning. District-level administrators had become interested in multimedia and had set up several multimedia courses, in addition to other computer courses, for teachers at all levels within the school system. These courses, available through a centrally located teacher resource center that was well-equipped with hardware and software, introduced teachers to multimedia tools and encouraged them to use these with their students and/or in the collaborative preparation of curriculum materials.[8] Notably, teachers received salary credit for participating in these and other courses. As a result, teachers in Hillcrest's school district considered themselves professionals, an important factor in motivating them to take on new challenges, such as multimedia computing. In addition, the school system as a whole had developed a program of "action research," in which selected teachers became active as researchers while developing new curriculum materials and activities. The current interest of the action research program was in the integration of computers into all major subject areas, focusing on one course per year.

Technical support also made a difference. The district was fairly well-equipped with computer hardware and software, and was able to contribute a video monitor, cables, and supplementary videodiscs to our multimedia system.

At the school level, the single most determining factor affecting the "quality of educational life" for Lucy and her students was the size of the class—seventeen students. It was this that allowed Lucy to foster a student-centered climate for learning, one that respected children as individuals, and hence as different kinds of learners who could benefit from different kinds of interactions and materials, including electronic multimedia. But other features of the school contributed greatly to the success of this multimedia experiment. The organization of space in the school building itself (built in the 1960s according to a unique design that features window-lined corridors radiating out from a central area to small classroom clusters) flexibly accommodated the "spill-over" of students who sometimes wanted to work in the shared public area just outside the classroom while our research was under way.

Inside Lucy's classroom, other features combined to create an ambience conducive to the integration of a multimedia workstation used, at most, by only a few students at a time. Her room lacked the overall grid-like structure that defines the traditional classroom, with rows of desks oriented to a clear front of the room where a larger desk, podium, and chalkboard designate the teacher as the central, controlling figure, as information source and sole arbiter of student contributions. Instead, Lucy's classroom was decentered in several ways. It was roughly circular in shape, with windows comprising about two thirds of the walls, and desks were arranged in clusters of four, with pairs of students facing each other or the windows; Lucy's desk was off to one side. Together, these features allowed the multimedia system, placed against one wall of the room near the door, to be perceived by Lucy and her students as another more or less natural addition to the classroom—neither a dominant focus of attention at the front of the room nor a marginalized object at the back. The presence of other equipment in the room also reinforced the sense that technologies were valuable tools to be used when appropriate. Several computers and a printer sat just outside the classroom in a common space, and were intermittently used by students to print out reports, work through simulations, and play games. A telephone on Lucy's desk rang from time to time, giving the feel of constant contact with the world outside the classroom. Freedom, flexibility, and a great deal of communication, therefore, characterized the overall organization of the classroom.

Role of the Software

Lucy, Sam, and Ralph concurred that the design of the software was a key factor in the students' success as multimedia authors, browsers, and game players. For Lucy, two of the most important features were the motivating, intrinsic interest of the materials, especially the visuals, and the clarity and responsiveness of the user interface.

> The visuals were so strong and great, and the kids got so excited about the experience that they even told their parents, and some came into school to see the program. Plus, it was user friendly and had quick control.

One crucial feature of the *Interactive NOVA* software was that it is relatively easy to use and can be learned by trial and error, hence by showing rather than by lengthy explanations. As Lucy described it, after her introduction, the children simply "took over" and wanted to investigate the software on their own. They did not ask for written support materials, such as a manual, as she had. One of the students, Laurie, became very proficient with the software quite quickly and almost immediately came to be thought of as the classroom Interactive *NOVA* expert. Although Lucy was on hand to help her, Laurie basically taught herself how to use the report-maker and video-editing tools, and found that she very much enjoyed customizing video clips for her own purposes. As Laurie said, "When I'm stuck, I try to figure it out myself rather than reading how to do it." When she had questions, Ralph helped her with some of the aspects of the video editor and showed her how to use the *Interactive NOVA* software tools with the two other videodiscs. In her role as expert, Laurie helped many of the other children with the technical aspects of the software when called upon to do so. Her advice to others was "go slowly because you'll figure everything out in time." Lucy's role became one not so much of providing technical guidance as providing guidance in the formation of small groups to use the software and keeping track of how long various children had used it so that everyone who wanted to could.

Finally, the authoring components of the *NOVA* materials compared favorably with most other multimedia tools that Sam and Ralph had encountered. Having tried to teach people to use other programs' video-editing features, Sam felt that "this is the nicest I have seen." He had often been frustrated by the lack of standardization among different software tools and felt that the Interactive *NOVA* report-maker and video-editing tools could well provide a standard. "Software," he said, "drives the industry, and this software is powerful and makes it work. We need more writing and indexing tools like this."

Role of the Researchers

Finally, the researchers themselves were active participants, as well as observers, in the multimedia experiment described here. Throughout the process, researchers helped students with small problems of software navigation and, occasionally, with the clarification of direction and purpose.

SUMMARY

In order to successfully integrate advanced interactive multimedia materials into classrooms, teachers and administrators must confront a wide range of challenges. Integration will be easy or difficult depending on the technical and social support available to the teacher, the design of the multimedia software itself, the structure of the individual teacher's classroom environment, and the quality of fit between the multimedia materials and ongoing classroom activities. This paper has described the results of a brief field study in which prototype multimedia materials were incorporated into a public elementary school classroom for a period of six weeks. Amply supported in each of the above areas, the materials were thoroughly absorbed into the classroom culture, and became vehicles for small-group activities as well as for the creation of original multimedia products that furthered students' research and expression.

Notes

1. Hillcrest was chosen as the site of our research because its school district had been successfully integrating computers into the ongoing curriculum for some time, and its staff was actively interested in multimedia computing. Since multimedia hardware and software are still relatively new and expensive, we chose to work in a school system that was already invested, financially and pedagogically, in this innovative area.

2. Before deciding on *Interactive NOVA*, teachers and researchers collectively previewed a range of multimedia design examples (see Wilson, K., & Tally, W. (1990). *Looking at multimedia: Design issues in several discovery-oriented programs*. New York: Bank Street College of Education, Center for Children and Technology). Different criteria entered into their choice: The science coordinators liked the breadth of *Interactive NOVA* and felt that it would be accessible to students of varying ages and learning styles; the researchers believed the clarity of the program's interface promised relative ease in navigating the material; and the classroom teacher felt the disc's emphasis on marine life could enrich her students' study of whales. Content and structure mattered for everyone. It was important that the images and sounds were rich and the text serious, and also that the program provided meaningful and compelling ways of interacting with them. In this regard, NOVA's software authoring tools were of particular importance. They compared favorably to similar tools in other programs in terms of clarity and ease of use. The science coordinators, whose job it was to promote curriculum innovation, were eager to have these tools become the focus of teachers' and students' work. The two additional videodiscs were included in order to supplement the images of whales on the NOVA disc, since they were the current topic of study in the class.

3. See Brunner, C. (1990, Nov.-Dec.). What it really means to "integrate" technology. *Technology & Learning*.

4. Lucy offered no explanation for why the students who chose not to use the system for authoring did so; she considered it an example of the individual variation that she routinely encourages, coupled with the timing of the work (which took place at the end of the school year, and immediately following the students' completion of another research and writing assignment). The relatively higher frequency with which girls used the system over boys (three out of four in the authoring work) was attributed by Ralph, one of the curriculum coordinators, to the likelihood that students perceived the work as writing-related (because Lucy introduced it this way), and that the girls as a group were more successful at and interested in writing than boys. This seemed to be borne out by our observations of, for example, typing skills, which were far stronger in the girls than the boys. For our purposes, however, it was important that the students who did use the system were quite different as learners, and yet became engaged in different ways.

5. While she appreciated the spontaneous, performatory element of the students' multimedia productions, Lucy also wished for more concreteness and permanency in the materials. She wanted students to be involved in a deep way with their writing tasks, and she needed the time and space to go over their writing in order to support them in this. She thought that the hard copies she had of the kids' multimedia reports were helpful, but not helpful enough. Without access to the visuals from the videodisc as well, it was frustrating for her as a teacher to be unable to look at student reports easily. This concern extended to the issue of the material's dependence on the computer hardware and software itself. As Lucy put it, "When the computer goes away, the report goes away." For this reason, she felt it would be important to have tools for making good demo tapes of student performances (e.g., a camcorder with multiple inputs) so that she could view the multimedia reports in their entirety more easily.

6. *"Laurie Island"* contained ten cards with associated images; eight of these were illustrated by motion clips. In presenting her report, Laurie read aloud from the text on the computer screen, looking back and forth from the computer to the video monitor, and to her audience.

7. Nancy and Helen's multimedia report consisted of thirteen cards comprised mostly of text from Nancy's previous report on narwhals, with references to complementary videodisc slides and motion clips. While the earlier work had involved, according to Nancy, two weeks of background library research and three days of writing, the supplemental research and writing of their multimedia report occupied parts of four days, including "one whole morning."

8. The district was also resource-rich: The teacher resource center where courses were held contained an impressive collection of graphics, animation, and multimedia software, plus three videodisc players (one in the junior high and two in the high school) as well as several video and still cameras. The high school art department had become particularly involved with multimedia. The computers in use were from the IBM PS/2 line (PS/2 25s and 30s) and from the Apple II series (IIgs and IIes.)

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